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Advanced Thermal Technologies for Future Space Science Missions at JPL

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A wide range of deep space science missions are planned by National Aeronautics and Space Administration for the future. These missions include several planetary orbiters, planetary landers and rovers, planet and comet flybys, and several planet and comet sample return missions. Many of these missions are being planned under a strict cost caps and advanced technologies are needed in order to enable these challenging missions. Because of the wide range of thermal environment the spacecraft experience during the mission, developing an appropriate thermal control system for the spacecraft is both complicated and challenging. Advanced thermal control technologies are the key to enabling many of these missions.

Several advanced thermal control technologies are being investigated and developed at the Jet Propulsion Laboratory for these future space science missions. These technologies are being developed for a wide range of spacecraft thermal applications. These applications include: temperature control, minimizing heat losses, precision temperature control of large structures, universal thermal architecture for future missions, microspacecraft thermal technologies, and micro-electromechanical systems based thermal technologies for micro/nano spacecraft.

Individual technologies are being developed for specific thermal control application on the spacecraft. In the area of heat transfer loops, the two technologies that are being investigated include loop heat pipes and mechanically pumped single-phase liquid loops. Miniature loop heat pipe technology is evaluated for microspacecraft and Mars lander and rover thermal control applications. Variable conductance loop heat pipe that uses a passive thermal control valve is being tested for rover battery thermal control. Mechanically pumped cooling loop technology that was successfully demonstrated on Mars Pathfinder is being further developed for longer life missions. A bearing and seal free pump is developed under NASA Small Business Innovative Research contract for space applications that require reliable long life pump. This pump is currently being tested at JPL Thermal Technology Laboratory.

In the area of variable emissivity devices and thermal switches, two specific technologies are being investigated. Electrochromic devices are being evaluated for their variable emissivity property for replacing thermal control louvers on future spacecraft. The cost and mass of electrochromic devices are an order of magnitude lower than that of the mechanical louvers currently used on spacecraft. A miniature heat switch is being developed for use on future microspacecraft applications under the NASA SBIR program. This heat switch technology is expected to reduce the heat switch mass by an order of magnitude compared to the current state-of-the-art heat switch technology.

High performance light weight thermal insulation is another technology that is very important for the future spacecraft, especially for future Mars landed missions. New insulation types consisting of aerogel and carbon dioxide as the insulation media are being examined. These new types of insulation reduce the mass by 50% compared to currently used batt thermal insulation.

In the area of micro-electro-mechanical-system based thermal technologies, a pumped liquid cooling system is being developed for removing heat from high power density electronics and other payload from future micro and nano spacecraft. This technology will enable to removes heat fluxes of over 20 Watts per square cm from the future spacecraft electronic payload.

The paper to be presented at the conference will describe the missions where these technologies will be used and the current status of their development at JPL.